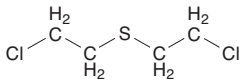
Mustard Gas

CAS No. 505-60-2

Known to be a human carcinogen

First listed in the *First Annual Report on Carcinogens* (1980)

Also known as bis(2-chloroethyl) sulfide



Carcinogenicity

Mustard gas is *known to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in humans.

Cancer Studies in Humans

In several epidemiological studies, exposure to mustard gas (through military use or occupationally) was associated with an increased risk of lung or other respiratory-tract cancer. Among mustard-gas production workers, the risk of respiratory cancer was higher in individuals who had been exposed to mustard gas for longer periods (IARC 1975, 1987). Since mustard gas was listed in the *First Annual Report on Carcinogens* and subsequently reviewed by IARC (1987), it has been reported to be associated with cancer at several other tissue sites. A cohort study in England found significant excesses of laryngeal, pharyngeal, upper-respiratory-tract, and lung cancer in workers employed in the manufacture of mustard gas during World War II (Easton *et al.* 1988).

Cancer Studies in Experimental Animals

Mustard gas caused cancer in mice of both sexes. When administered by inhalation or intravenous injection, it caused lung tumors, and when administered by subcutaneous injection, it caused tumors at the injection site (fibrosarcoma or sarcoma) (IARC 1975, 1987).

Studies on Mechanisms of Carcinogenesis

Mustard gas caused genetic damage in all systems in which it was tested. It caused DNA damage in bacteria and gene mutations in fungi. In *Drosophila melanogaster,* it caused dominant lethal mutations, sex-linked recessive lethal mutations, aneuploidy, and heritable translocations. In cultured rodent cells, it caused mutations, chromosomal aberrations, and DNA damage. In mice exposed by intraperitoneal injection, mustard gas was shown to bind covalently to DNA, RNA, and protein (IARC 1987).

Properties

Mustard gas is a suflur mustard alkylating agent that exists at room temperature as a colorless to yellow oily liquid with a sweet, agreeable odor (IARC 1975). It is insoluble in water, soluble in acetone, benzene, ethanol, ether, and other common organic solvents, miscible in petroleum ether, and highly soluble in lipids. It hydrolyzes readily in aqueous solution (Akron 2009). Physical and chemical properties of mustard gas are listed in the following table.

Property	Information
Molecular weight	159.1[a]
Specific gravity	1.2741 at 20°C/4°C (liquid) 1.338 at 13°C (solid)[a]
Melting point	13°C to 14°C[a]
Boiling point	215°C to 217°C[a]
Log K_{ow}	2.41[b]
Water solubility	0.000684 g/L at 25°C[a]
Vapor pressure	0.11 mm Hg at 25°C[a]
Vapor density relative to air	5.4[a]

Sources: [a]HSDB 2009, [b]ChemIDplus 2009.

Use

Mustard gas is a vesicant (blister-inducing agent) first used in chemical warfare in World War I. It was also used in chemical warfare in Ethiopia in 1936 and in the Iran–Iraq war from 1984 to 1988. Small amounts are used in research as a model compound in biological studies of alkylating agents. Mustard gas was tested as an anticancer agent, but its clinical use was not successful because of its high toxicity (IARC 1975, ATSDR 2003).

Production

By the end of World War I, daily U.S. production of mustard gas had reached about 18,000 kg (40,000 lb). The United States continued to produce and stockpile mustard-gas chemical weapons until 1968, accumulating more than 34 million pounds (ATSDR 2003). The United States no longer produces, imports, or exports mustard gas and signed the International Chemical Weapons Convention treaty in 1997, which mandated destruction of all chemical weapons by 2007 (CDC 2010). In 2009, mustard gas was available in research quantities from U.S. supplier (ChemSources 2009).

Exposure

The primary routes of potential human exposure to mustard gas are inhalation and dermal contact; however, the general population typically is not exposed to mustard gas. Aging stockpiles of mustard gas are stored at eight U.S. Army bases and are scheduled for destruction. Although the greatest risk of exposure to date has been among military personnel, there is some small risk of exposure for people living near military installations where mustard gas is stockpiled and destroyed or in the event of accidental releases or a chemical-warfare attack. People may also be exposed to residues of mustard gas disposed of in bulk quantities years or even decades ago if these disposal sites are disturbed (ATSDR 2003, HSDB 2009).

Bullman and Kang (1994) reviewed the effects of mustard gas and other hazards on U.S. military personnel. During World War I, as many as 28,000 of the American Expeditionary Forces were exposed to mustard gas, but seldom to lethal concentrations, because the gas was dispersed on the battlefield. Although mustard gas was not used in World War II, the United States produced and stockpiled it for possible use and conducted research to prepare for the threat of chemical-warfare attack. Top-secret experiments to test protective equipment, clothing, and antivesicant ointments, involving patch or drop tests, chamber tests, and field tests, were conducted with military volunteers. In the patch or drop tests, which assessed the strength of protective ointments, 15,000 to 60,000 soldiers and sailors were exposed to mustard gas. In chamber tests, protective masks and clothing were evaluated by exposure of volunteers to the chemical in a gas chamber for an hour or more every day or every other day until penetration was observed, evidenced by moderate to intense chemical burns on the skin. The same outcome was sought in field tests of the quality of masks, protective clothing, and ointments, which required soldiers to cross tropical or subtropical lands where the gas

was dropped. In chamber and field tests, at least 4,000 servicemen were exposed to mustard gas.

Regulations

Environmental Protection Agency (EPA)

Emergency Planning and Community Right-To-Know Act

Threshold planning quantity (TPQ) = 500 lb.
Reportable quantity (RQ) = 500 lb.
Toxics Release Inventory: Listed substance subject to reporting requirements.

Resource Conservation and Recovery Act

Listed as a hazardous constituent of waste.

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